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EDITORIAL

Retail operations

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Retail operations emerged as a substantial area of research in recent years. There are several drivers of this advent. Retailing is a significant economical sector in which changes in markets, companies, processes and products occur rapidly. The retail industry is a thought leader in the development and design of advanced operations concepts and processes since the 1990s. Firms like Amazon, Zara, Tesco, Aldi or Walmart are on the forefront of operational innovations, adopted in many other industries. In the last decade, e-commerce and omni-channel retailing, technological advances and the rise in big data have changed retail practice, operational requirements and its competitive landscape.

Generally, retail operations involve highly complex tasks at the interface between sales, marketing and logistics. It has unique elements, such as direct interaction between customers and logistics (e.g., for attended home delivery, in-store

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inventory management, store execution and backroom planning), fulfillment across channels (e.g., omni-channel retailing) or usage of innovative technologies (e.g., multi-compartment vehicles, advanced order picking systems). Furthermore, different decision makers from different organizational functions and hierarchical levels such as, logistics planners, store managers or category managers, are involved in orchestrating the information and product flows between the point of production, warehouses, shelves and the point of consumption. The optimal design and execution of retail operations need to comprehensively take into account consumer, technical and business perspectives.

Because of this complexity, more comprehensive approaches are becoming relevant in retail planning. The continued need to improve the efficiency of operations, their practical need to support decision making in retail operations, and the growing availability of data motivate an increasing number of scientists and practitioners to intensify research on demand and supply-related issues in retail and consumer goods industries. Operations research with its roots in optimization, statistics and informatics contributes to more effective and efficient retail systems.

The objective of this special issue of OR Spectrum is to accelerate the development of quantitative approaches for problem-solving and decision making for such applications. This special issue contains a selection of papers that have the potential to better understand retail problems at hand. It also supports to improve the quality of decisions in retail and consumer goods industry. Each of the selected papers deal with planning problems in retail operations at the interfaces with customer management (Steiner et al. 2018; Corsten et al. 2017), store management (Wensing et al. 2018; Turgut et al. 2018), distribution planning (Klein et al. 2017; Ostermeier et al. 2018; Koch et al. 2018; Soriano et al. 2018) and warehousing and picking (Schubert et al. 2018; Boysen et al. 2017). In particular, this special issue addresses the following topics:

Flexible estimation of time-varying effects for frequently purchased retail goods: A modeling approach based on household panel data Steiner et al. (2018) develop an innovative approach for demand estimation. They address varying demand in brand choice modeling due to changing preferences, price sensitivities over time and special occasions (e.g., public holidays) by proposing a flexible multinomial logit model. Both time-varying brand constants and time-varying effects of covariates are modeled using penalized splines, a flexible, yet parsimonious, nonparametric smoothing technique.

Assortment planning for multiple chain stores Assortment planning deals with the selection of products for each channel and category. Retailers define assortments for a single store or jointly for multiple chain stores where demand varies between stores. Corsten et al. (2017) address the trade-off between expensive, customized assortments in every store and inexpensive, identical assortments in all stores, which, however, neglects demand variation of each store. They formulate a model for the regionalized assortment planning problem with capacity constraints and substitution effects. In the approach, a common assortment that is supplemented by regionalized products is selected. The strongly NP-hard problem is solved with different algorithms and methods for obtaining approximate solutions and solving large-scale instances.

Optimizing case-pack sizes in the bricks-and-mortar retail trade Before reaching the store, products generally flow through the retail distribution system as larger bundles, the so-called case packs. In several studies, these case packs are identified as

having a significant impact on distribution logistics efficiency. Wensing et al. (2018) develop an approach for determining optimal case-pack sizes in grocery retailing. The model captures the relevant operative cost drivers along the internal supply chain of a large bricks-and-mortar retailer and time-varying demand over a business week. The approach bases on a periodic review reorder point policy applied in a stationary cyclic version. Exact and approximate methods are developed to identify optimal and near-optimal case-pack sizes for individual and multiple stores. The latter case is especially relevant, if the retailer operates a one case-pack size for all stores strategy.

Data-driven retail inventory management with backroom effects The backroom effect constitutes the handling effort of a replenishment that does not fit on the shelf of a retailer. This effect needs to be included in the decision making of inventory policy parameters as it influences the handling effort, which constitutes a major part of the retailer's operational cost. Turgut et al. (2018) propose a data-driven model to calculate the parameters of a periodic review policy while considering the backroom effect. This policy triggers an order when inventory drops below the reorder point and the can-order point, where the order comprises the smallest integer number case packs that brings the inventory level to or above order-up-to level. As retailers face stochastic non-stationary demand, a data-driven approach based on historical data is applied to this joint replenishment problem and benchmarked against other simple rules. The results show that ignoring uncertainty and the backroom effect can lead to significant cost increases.

A model-based approximation of opportunity cost for dynamic pricing in attended home delivery Klein et al. (2017) develop a model for online retailers facing the problem of attended home delivery considering dynamic pricing for the time slots. They present a cost approximation approach based on mixed-integer linear programming. This approximation combines the most current information regarding the customers accepted and with a forecast of expected customers to come that is adapted during the progress of the booking horizon. Vehicle routing costs are approximated by a dynamic seed-based scheme in which distances approximations are dynamically adjusted for already accepted and potential new customers.

Loading constraints for a multi-compartment vehicle routing problem Multi-compartment vehicles can deliver several product segments jointly. Retailers use multi-compartment vehicles to jointly transport different temperature zones (e.g., deep-frozen and ambient products). Each product segment is then transported in a separate compartment. The size and position of the compartments can be adjusted for each tour with the use of flexible compartments. However, this requires that the compartments and each particular order can be accessed for loading at the warehouse and unloading at the customer stop. Ostermeier et al. (2018) develop a model that determines the loading sequence of customer orders to each compartment and the vehicle routing.

A hybrid algorithm for the vehicle routing problem with backhauls, time windows and three-dimensional loading constraints Retail stores are usually supplied by a central warehouse, and they wish to return packaging material. Koch et al. (2018) deal with such a vehicle routing problem where customers receive items from a distribution center and at the same time return items back to the distribution center. Besides considering the challenge of delivering and picking up items simultaneously on the same vehicle, they incorporate three-dimensional loading constraints and time windows. In order to

avoid any reloading effort during a tour, they consider two different approaches for loading the vehicles: (i) loading from the back with separation of the loading space into a delivery section and a pickup section and (ii) loading from the (long) side. A hybrid algorithm is proposed consisting of an adaptive large search for the routing and different packing heuristics for the loading part of the problem.

The two-region multi-depot pickup and delivery problem Motivated by the increasing complexity of transportation networks and the problems faced nowadays by transportation companies, Soriano et al. (2018) develop a two-region pickup and delivery problem. Specifically, a region refers to an area where customers and distribution centers are located, but no direct transportation between customers belonging to different regions is allowed. Pickup and delivery locations of each request lay in different regions. Therefore, they can not be served on the same intra-region route, and a long-distance transportation must exist between the clusters for the requests to be serviced. The authors study the problem where these two interrelated decision are to be made to minimize the total cost for long- and short-distance transportation.

Integrated order picking and vehicle routing with due dates Retail stores typically order their goods from a central distribution center. Each order comprises information about the set of items and the due date. Whether and to which extent a due date is tardy depends on the composition of the tours, the corresponding routes and the start dates of the tours (vehicle routing subproblem). The start date of a tour, however, is also affected by the assignment of orders to pickers in the distribution center and the sequence according to which the orders are processed by the pickers (order picking subproblem). Although both subproblems are closely interconnected, they have not been considered simultaneously in the literature so far. Schubert et al. (2018) develop an iterated local search algorithm for the simultaneous solution of the subproblems, show the computational efficiency and point out in which cases an integrated solution is beneficial.

Deep-lane storage of time-critical items: one-sided versus two-sided access Boysen et al. (2017) propose a storage assignment model for a retail distribution center of a food retailer. They investigate the case where pallets of food are intermediately stored overnight and assembled during the following day according to the respective store demands. To save cooling costs, deep-lane storage in some compact storage system is applied, from which the pallets are to be retrieved the next morning when the trucks servicing the stores are to be loaded under great time pressure. To enable an efficient retrieval process, storage assignments are defined for the put-away of pallets in the deep-lane storage system, such that blockings, i.e., a pallet with later retrieval time is placed in front of another pallet with higher priority in the same lane, are avoided. The authors formalize retail storage assignment problems, investigate computational complexity, introduce solution procedures and quantify the increase in flexibility promised by a two-sided access.

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